1884MNRAS..45...29P

The remaining eleven stars are not in Argelander.

The smallest star photographed is probably not much above the 11th mag. Looking at the field with a 5-inch refractor, many of the stars seemed minute. On the focussing glass of the camera the Milky Way appeared as a bright glow, and this is plainly visible as a bright nebulosity on the print.

A Photometric Comparison of the Light transmitted by certain Refracting and Reflecting Telescopes of Equal Aperture. By Prof. C. Pritchard, D.D., F.R.S.

In a communication to the Society respecting the Oxford observations of stars occulted by the Moon during its recent total eclipse, I had occasion to mention the occultations of four faint stars, three of them approaching the twelfth magnitude, and not included in Dr. Döllen's list, and not found in any catalogue with which I am acquainted. Of these four stars one only was distinctly seen in the De la Rue Reflector of 13-in. aperture, although the other three were sufficiently salient to admit of observation during the eclipse by the Grubb Refractor of 12¼-in. aperture, and of their subsequent identification by means of that instrument.

This circumstance directed my thoughts once more to the long-agitated question concerning the relative light capacities of reflecting and refracting telescopes of approximately equal aperture. There being "nothing new under the Sun," I half expected to find that the question had long since been finally settled, and that there was no need of further research. On inquiring in those quarters where I thought the information, if it existed, would be possessed, and on referring so far as I could to written authorities, I came to the conclusion that the comparisons in question had up to the present time been conducted on insecure bases, and in fact were simply conjectural. Dr. Robinson, the late distinguished astronomer of Armagh, and who, I believe, would be admitted to be among the most reliable authorities on the question, thus writes in the *Monthly Notices* for May 1876:—"William Struve thought that the Dorpat Telescope of 9·6-in. aperture might be compared to Herschel's 20-ft. Reflector of 18-in. aperture;" and he adds, "We are told that M. D'Arrest's Achromatic of 11-in. aperture is very superior to Herschel's 20-ft. Telescope, and almost equal to the great telescope of Lord Rosse." Again, in the *Philosophical Transactions* for 1869 we find the same high authority, in his memoir on the great Melbourne Telescope, writes as follows:—"If we seek any comparison of the light of the two kinds of telescopes, based on actual measures, little is to be found but vague conjectures; thus M. Otto Struve *thinks* that Mr. Lassell's Telescope of 2-ft. aperture is nearly equal to the light of the Pulkowa 16-in." Dr. Robinson, in the *Monthly Notices* already cited, goes on to express

1884MNRAS..45...29P

a hope that as the Paris Observatory would soon be in possession of two magnificent instruments of both kinds, the question of their relative light capacity would soon be set at rest. I am not aware that this hope has been practically realised. Moreover, I believe that a committee was appointed by the British Association for the prosecution of a kindred inquiry, but I cannot find that a report has been actually published on the subject.

In the middle of these wide, not to say somewhat wild, conjectures, it occurred to me that the Observatory under my direction at Oxford is in possession of a photometer especially adapted to the determination of the question at issue; and, thanks to the generosity of Dr. De la Rue, possesses also two mirrors—the one of metal, which has done such excellent work in the hands of its donor, and also a silver-on-glass speculum (by With) of the same dimensions and of nearly equal excellence. With these means before me I determined to make the necessary measures, with a strong expectation of success.

Accordingly, immediately after the eclipse referred to, I requested my two able assistants, Mr. Plummer and Mr. Jenkins, whose experience now extends over many thousand photometric measures, to prepare a convenient list of stars, varying in magnitude from the second to the sixth, and, by means of them, measure their relative light-intensities as transmitted by the three instruments, viz. the Grubb Refractor of $12\frac{1}{4}$-in., and the two mirrors of about the same aperture, and already described.

The process which I arranged was as follows:—

Each of the two observers, armed with his own wedge photometer with its eyepiece attached, observed on it the point of extinction of each of the selected stars in each of the three instruments. Five extinctions were observed in the case of each star, and the resulting mean was adopted. From these data the relative light capacities of the three instruments were computed, on the principles and after the manner indicated in my memoir in the 47th volume of our Society's *Transactions*.

The observations made by Mr. Plummer and Mr. Jenkins possess the same degree of close accordance which has hitherto characterised their photometric work, and leave no doubt on my mind as to the accuracy of their conclusions.

The results are as follows:—

Light transmitted by the Grubb Refractor, $12\frac{1}{4}$-in. aperture : Light transmitted by the De la Rue Reflector 13-in. aperture :: 1·89 : 1

Light transmitted by the Grubb Refractor, $12\frac{1}{4}$-in. aperture : Light transmitted by the silver-on-glass mirror 13-in. aperture :: 1·5 : 1

The average deviation of the individual measure from the adopted mean does not exceed the light indicated by about $\frac{1}{20}$th of a "magnitude" on Pogson's scale.

It ought here to be remarked that the De la Rue metallic

1884MNRAS..45...29P

mirror has now been in constant use for upwards of thirty years, though still in a very serviceable condition. The silver-on-glass speculum, by With, is in a high state of polish; moreover, it has long been known that the reflective power of silver exceeds that of speculum metal, and this also no doubt is the case (though possibly not to an equal extent) with chemically deposited silver on glass.

Further, it will be observed that I have not here entered upon the general question of comparing achromatic object glasses with mirrors, whether of speculum metal or of deposited silver; I have confined the question to the large telescopes with which I am necessarily familiar, though I have little doubt they may be regarded as representative instruments. It is probable that no two object glasses, and no two mirrors, will be strictly alike in respect of light capacity, though possessing a general family likeness.

Nor have I here attempted to obtain the ratio of the amount of the light incident on the mirror or the object glass to that which is reflected from, or refracted through it, simply as a mirror or an object glass; therefore I do not touch on the question of the relative photographic values of the two kinds of instruments; but I repeat that I have confined my investigation to the relative amounts of light passing through the eye-lenses of the respective instruments. I am here treating of three telescopes and not of photographic cameras; still less am I here pretending to decide as to the relative superiority of the two forms of telescope. There are, however, two important remarks made by the late Dr. Robinson in the *Monthly Notices* to which I am disposed to give my entire assent. The one is, that in proportion as the apertures of the two sorts of instruments are greatly increased, the superiority of the light-transmitting power of the Refractor becomes less and less over that of the Reflector. Few persons are probably aware of the considerable loss of light in its passage through an object glass, on account of surface reflections and absorption of light by the materials. The latter loss of light increases, after a geometrical ratio, with the thickness of the glass; and this augmentation of thickness also necessarily increases at a rapid rate with any increase of aperture. From this peculiar idiosyncrasy reflectors are free; and no doubt if it were possible to sufficiently increase the aperture of an object glass, there must at length arise a thickness of glass material which will absorb more light than is lost by reflection from the speculum. This limit, however, is probably practically unattainable by any otherwise good object glass capable of being manufactured and figured; whereas the possible limits to the aperture of a reflector are at present not only not attained, but even as yet unsuspected. I agree consequently with the eminent philosopher of Armagh in the opinion that attention may in future be most profitably directed to the increase of the aperture of mirrors whether parabolic or plane, for the extension of our knowledge in astronomical physics.

1884MNRAS..45...29P

The following Tables contain the particulars of the individual measures on which the results referred to in the foregoing statements are founded.

TABLE I.

Comparison of the Light transmitted by the Grubb Refractor of 12¼-in. aperture and the De la Rue Reflector of 13-in. aperture.

Star selected.	Tabular mag. of Star selected.	Diff. of Light expressed in mag. Wedge A.	Ratio of the Lights transmitted.	Diff. of Light expressed in mag. Wedge B.	Ratio of the Lights transmitted.
β Andromedæ ...	2·2	0·76	2·01 : 1	0·68	1·87 : 1
g Pegasi ...	2·5	0·61	1·76 : 1	0·70	1·91 : 1
θ Andromedæ ...	4·5	0·75	2·00 : 1	0·83	2·15 : 1
32 Andromedæ ...	5·5	0·63	1·79 : 1	0·70	1·91 : 1
75 Piscium ...	6·2	0·67	1·85 : 1	0·68	1·87 : 1
Mean ...		0·684	1·88 : 1	0·718	1·94 : 1
		Av. dev. 0$^{\mathrm{m}}$·06		Av. dev. 0$^{\mathrm{m}}$·05	

TABLE II.

Comparison of the Light transmitted by the Grubb Refractor of 12¼-in. aperture and the De la Rue Telescope with the Silver-on-Glass Mirror (With), also 13-in. aperture.

α Aquarii ...	3·0	0·47	1·54 : 1	0·49	1·57 : 1
π Pegasi ...	4·1	0·40	1·45 : 1	0·42	1·47 : 1
59 Pegasi ...	5·3	0·49	1·57 : 1	0·56	1·67 : 1
Mean ...		0·453	1·518	0·49	1·57 : 1
		Av. dev. 0$^{\mathrm{m}}$·04		Av. dev. 0$^{\mathrm{m}}$·05	

From hence it appears that the light transmitted by the Refractor of 12¼-in. aperture : that transmitted by the De la Rue Telescope with a 13-in. metallic speculum :: 191 : 100; and in the case of the 13-in. silver-on-glass mirror (by With) 155 : 100.

I will now only quote a concluding remark made by Dr. Robinson in the *Monthly Notices* already cited, to the effect that comparisons such as are here instituted can only be effectually made where the two forms of instruments are set, as it were, side by side: "The comparison can only be fairly made (he truly says) when the conditions are identical; when the locality, the night, the object, the observers are the same; and, I may add, when there is no personal or party bias in the judge." I trust these conditions are well secured in the research detailed in the present communication.

Postscript.—On the reading of the above paper to the Society, a long and interesting discussion took place, in the course of which it became evident that some misapprehension existed as to

1884MNRAS..45...29P

the nature and use of the photometer employed. In order, therefore, to remove any doubts as to the exact meaning and scientific character of the measures recorded in the paper, I may observe that the bases of the cones of light proceeding from the stars on to the eye-lenses of the photometers as measured by a dynamometer, in the case of the Grubb instrument, are fairly represented by one-thirtieth of an inch, and in the case of the Reflector (with either mirror) by one-twentieth of an inch: between them and the eye, close to these small luminous circles, the photometer wedges traverse; and furthermore, close to the wedge is placed the eye of the observer, guided and restricted in direction by a small diaphragm with about one-tenth of an inch circular opening. It is certain, therefore, that the whole of the light incident on the object-glass or mirror passes through the wedge and through the pupil to the retina.

I cannot, myself, conceive a more perfect or simple form of a photometer; and, as to the skill with which it is handled, the observations in the text, printed from the note-books of the two able observers, speak to the initiated for themselves.

Since writing the above, I have measured photometrically the ratio of the incidents to the transmitted light of the Grubb 13-in. object glass, and I find the result in very good accordance with that obtained by Dr. Robinson in 1869 for the same object glass by a totally different form of photometer. This and a few similar investigations I propose to make the subject of my next communication to the Society.

Note on a Comparison of the Photometric Magnitudes of the same Stars Observed at Harvard College and at the University Observatory, Oxford. By Prof. C. Pritchard, D.D., F.R.S.

The total number of stars of which the magnitudes have been photometrically measured, both at Harvard College and at Oxford, is up to the present time 1,801.

Of these the number of accordances within one quarter of a magnitude is 1,569; within the tenth of a magnitude the number of accordances is 717.

The number of discordances amounting to a quarter of a magnitude, and less than four-tenths, is 168 out of the 1,800.

The number of discordances amounting to four-tenths of a magnitude and beyond is 64.

Among the probable or possible causes of these discordances, comparatively inconsiderable as they are, may be reckoned:—

1. Errors of observation at one or both Observatories, as shown by the considerable residuals recorded in the Harvard memoir, and by the variable but smaller "average deviations" printed in the Oxford work.
2. The general application of the mean value of the atmospheric absorption on individual nights, whereas this